Comparison of
Multiblock Grid & Domain Decomposition
in
Coastal Ocean Circulation Modeling

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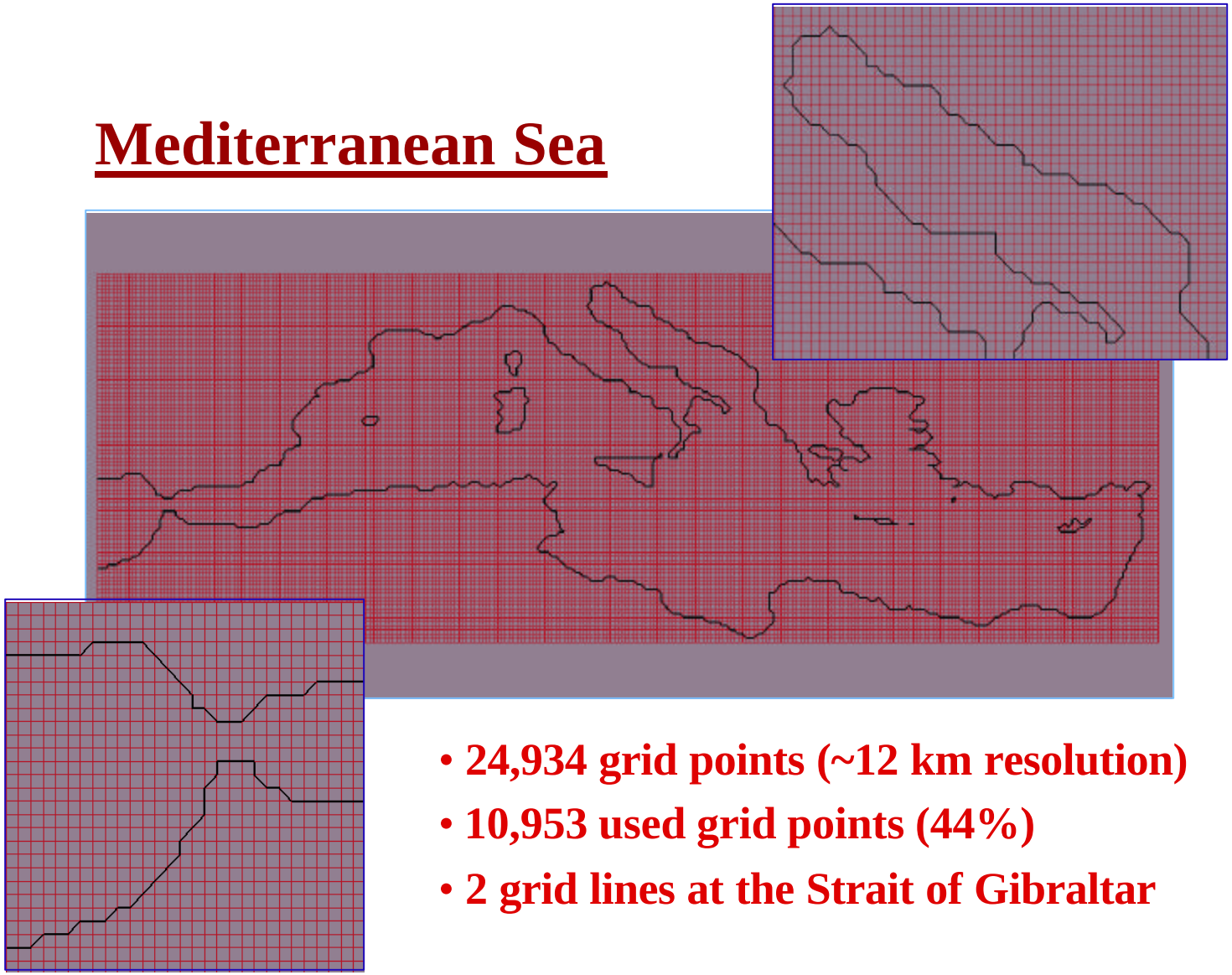
Outline

- Problems:
  - Poor resolution, less accuracy
  - Not sufficient for planning military operation
  - Large memory and processing requirements
- Solutions:
  - Nesting Techniques
  - Domain Decomposition
  - Multiblock Grid
- Comparison:
  - U.S West Coast Domain Decomposition
  - U.S West Coast Multiblock Grid

Mediterranean Sea



- 24,934 grid points (~12 km resolution)
- 10,953 used grid points (44%)
- 2 grid lines at the Strait of Gibraltar

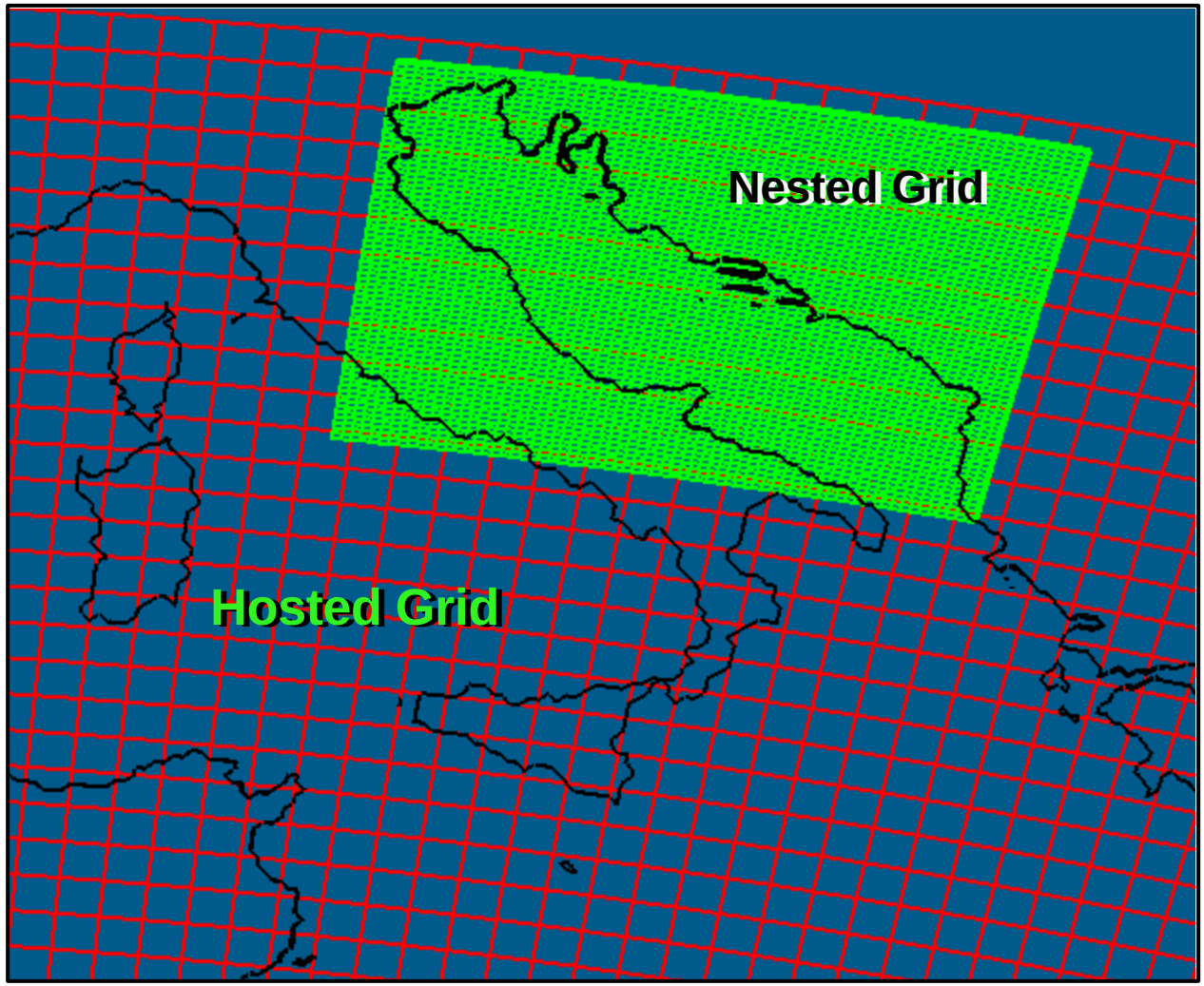
Arabian Gulf

- 61,401 (total)
- 39,092 (unused)
- 22,309 (used)
- 36% of total

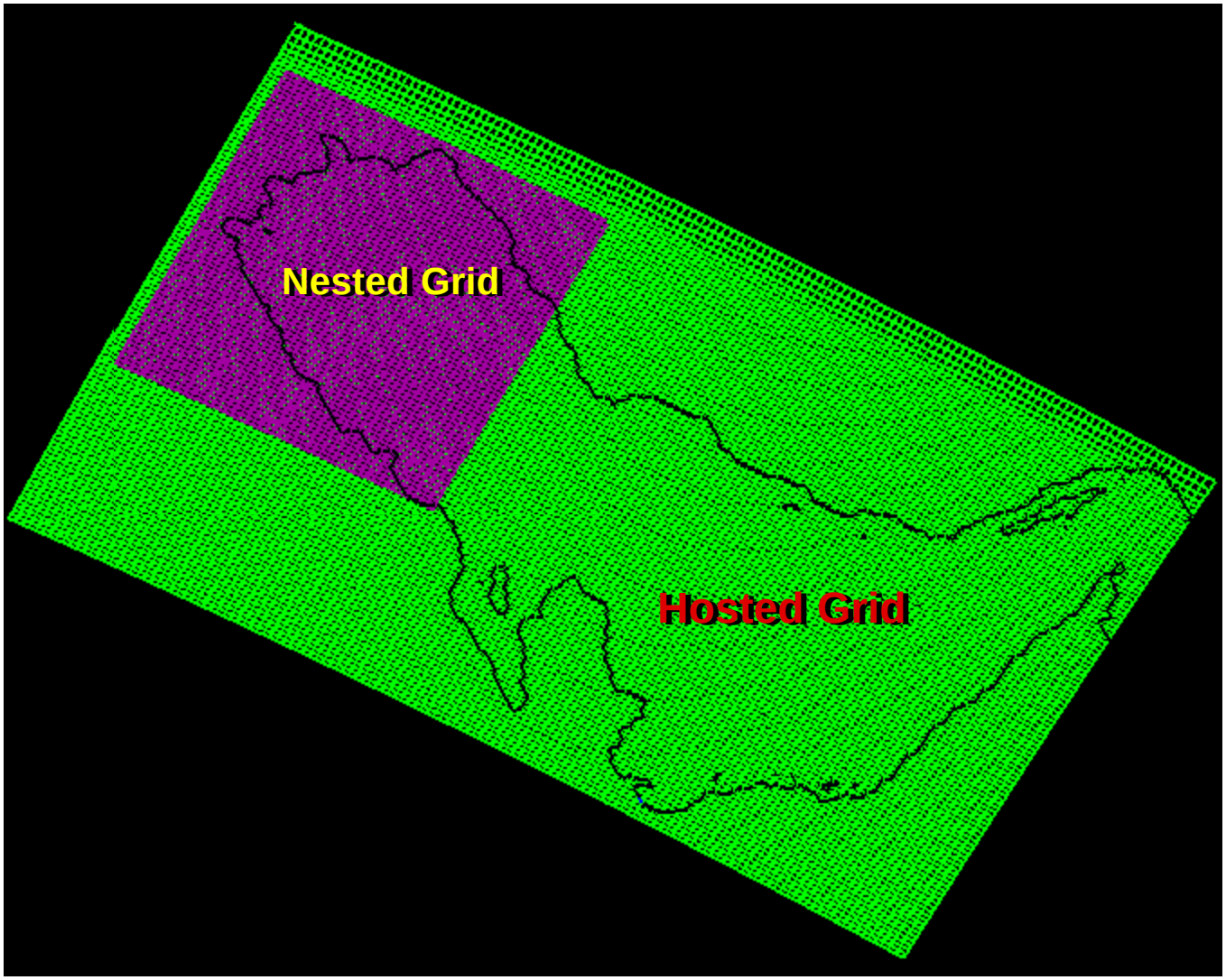
Nesting Technique:

- Use fine grid within area of concern (nested grid)
- Use coarse grid elsewhere (hosted grid)

Adriatic Sea Nesting



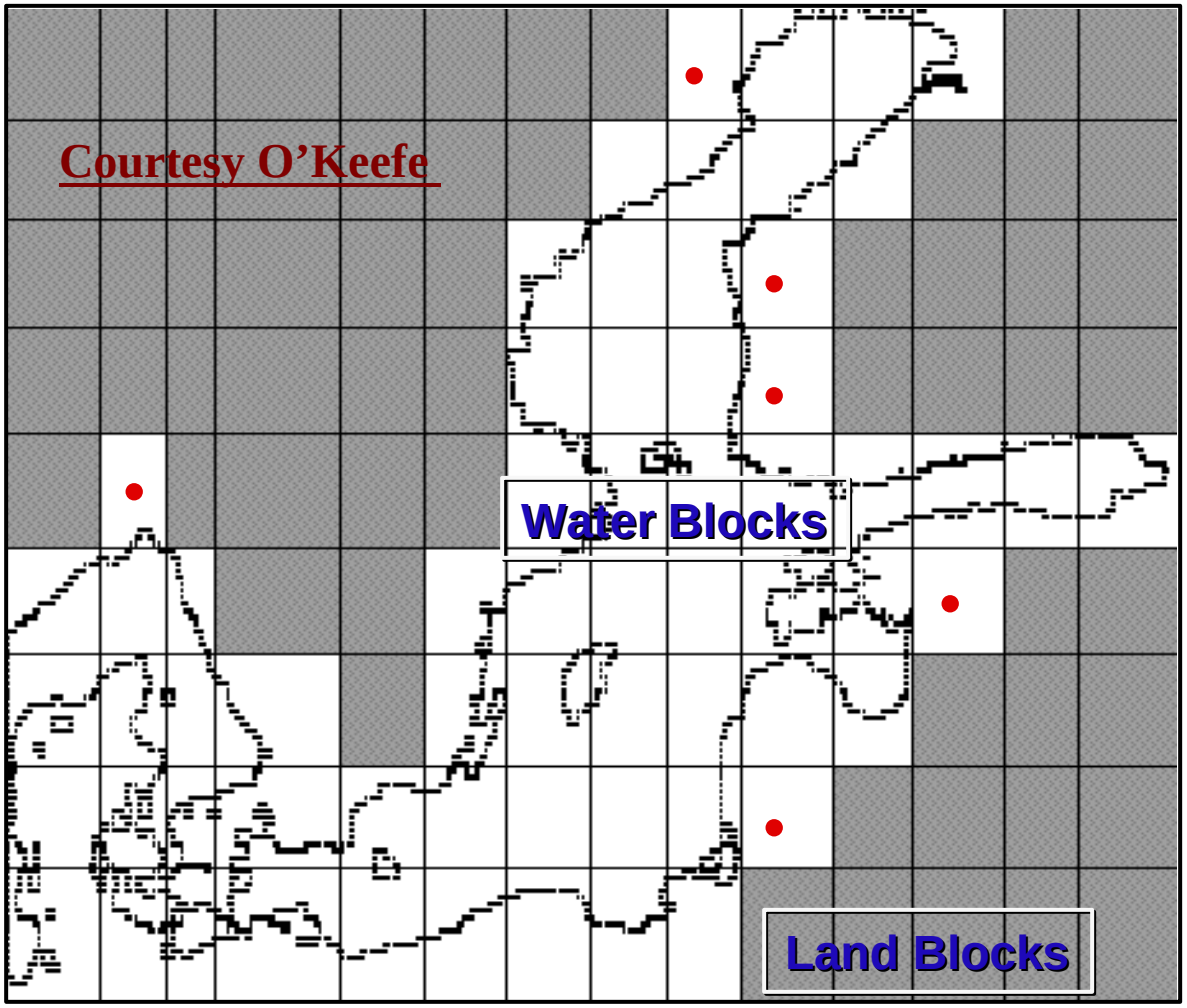
Arabian Gulf Nesting



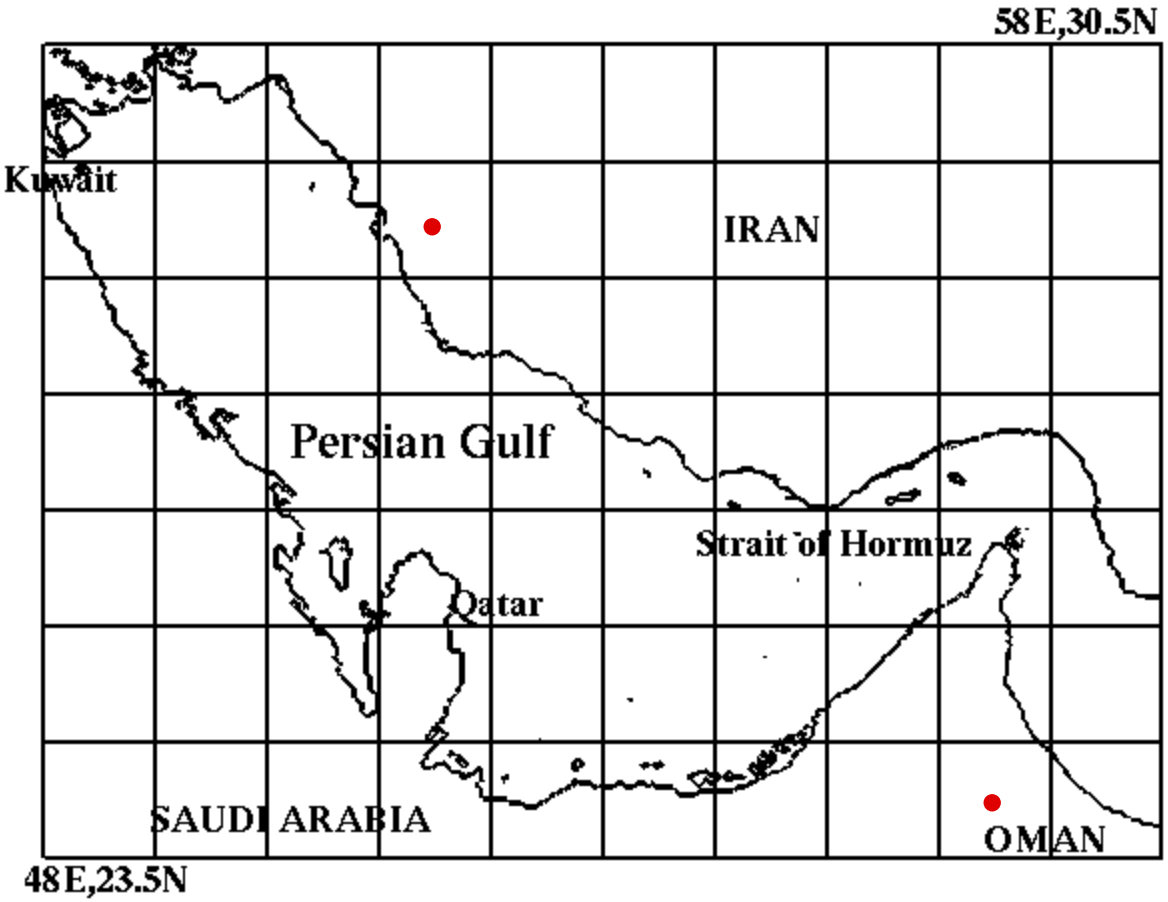
Domain Decomposition:

- Breaks grid and initial data into sub-blocks
- Complicated preprocessing step
- Indices bookkeeping
- Work distribution
- Severe load imbalance
- Interface communication (only one)

Baltic Sea



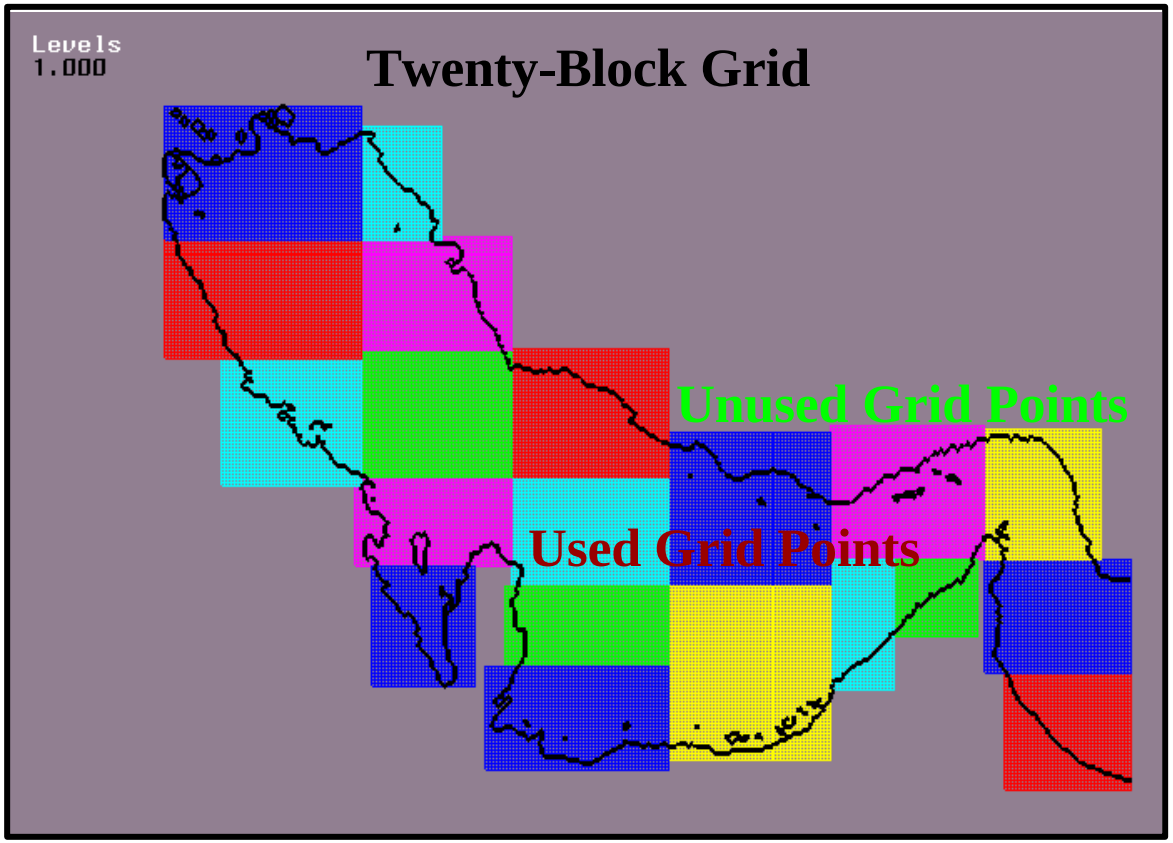
Arabian Gulf



Multiblock Grid:

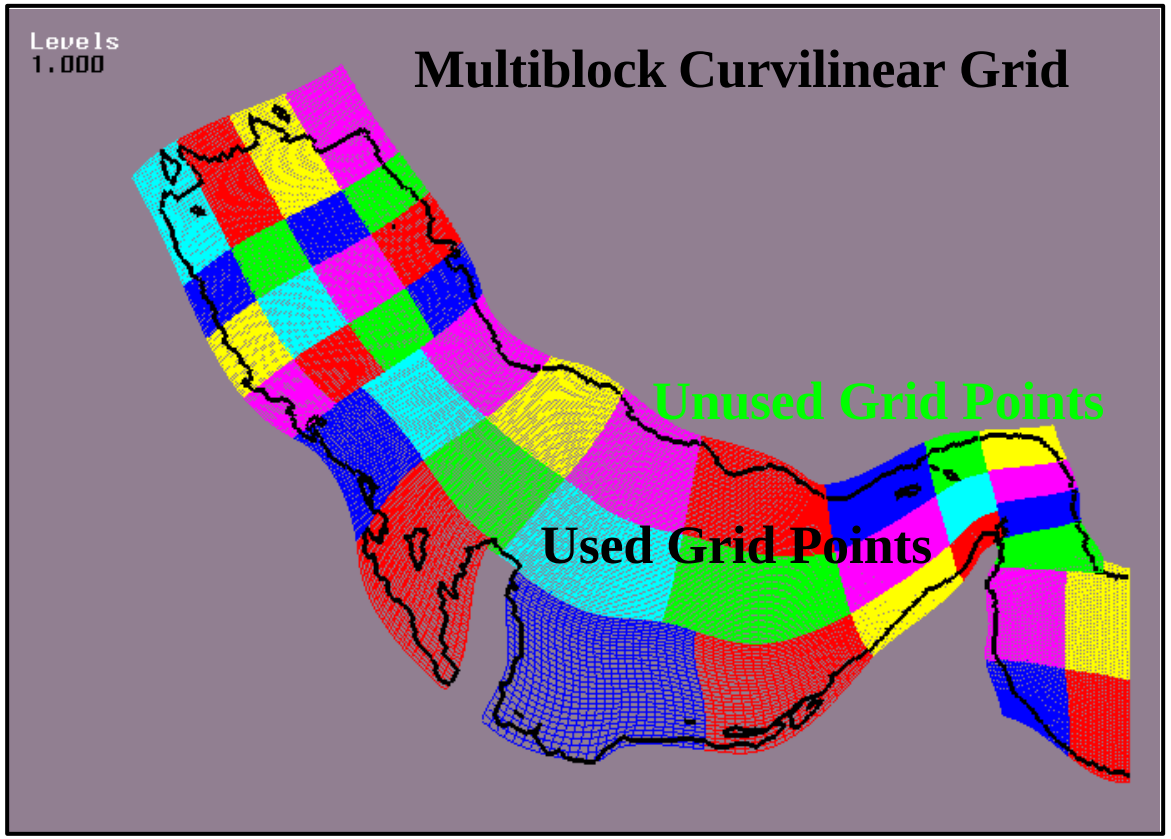
- Generate sub-block grid
- Generate initial data for each sub-block
- Grid blocks can better cover complex coastlines
- Easily handle high resolution areas of interest
- Interface communication (more than one)

Arabian Gulf



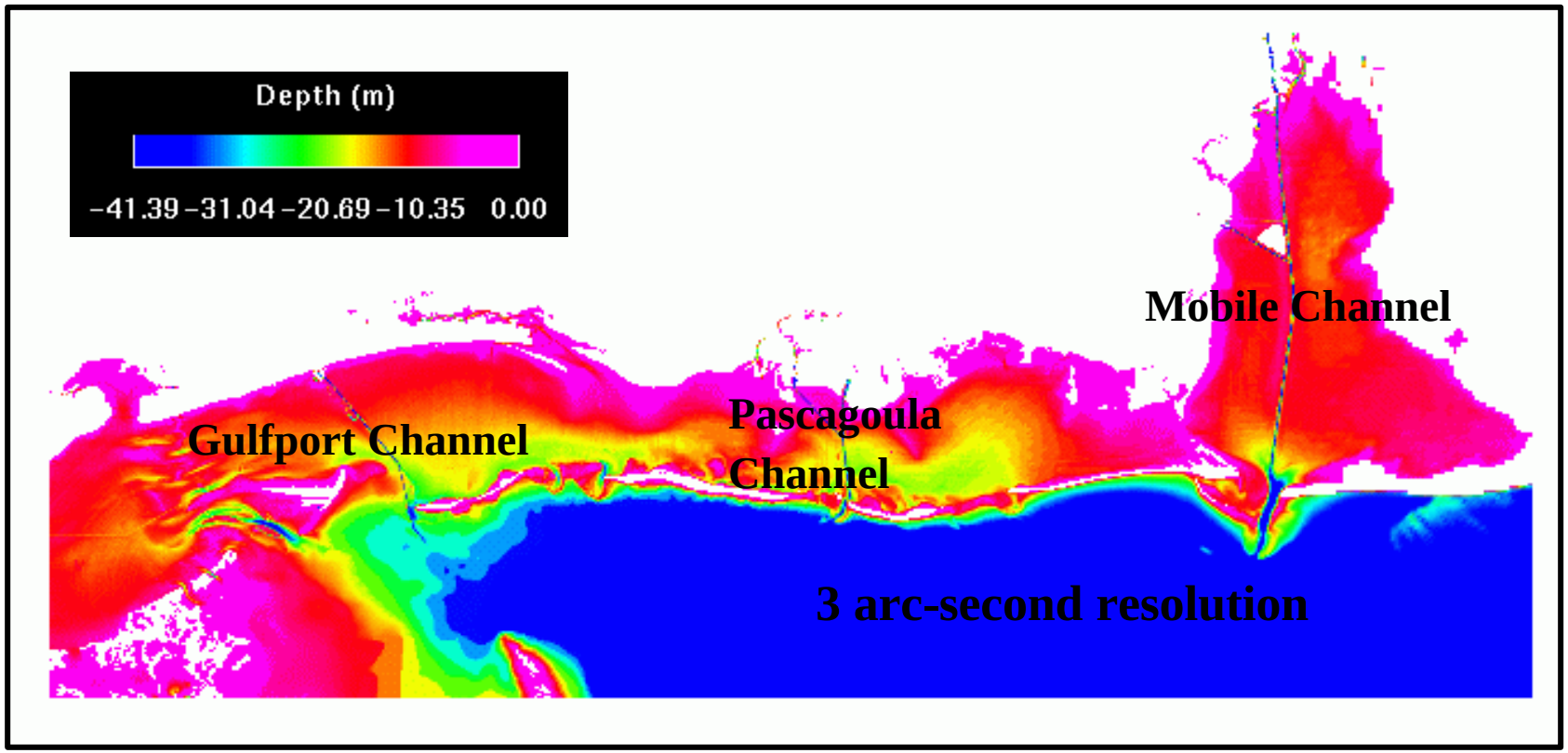
- 32,031 (total)
- 9722 (unused)
- 23X MPI-Only
- 57X MPI-OpenMP

Arabian Gulf

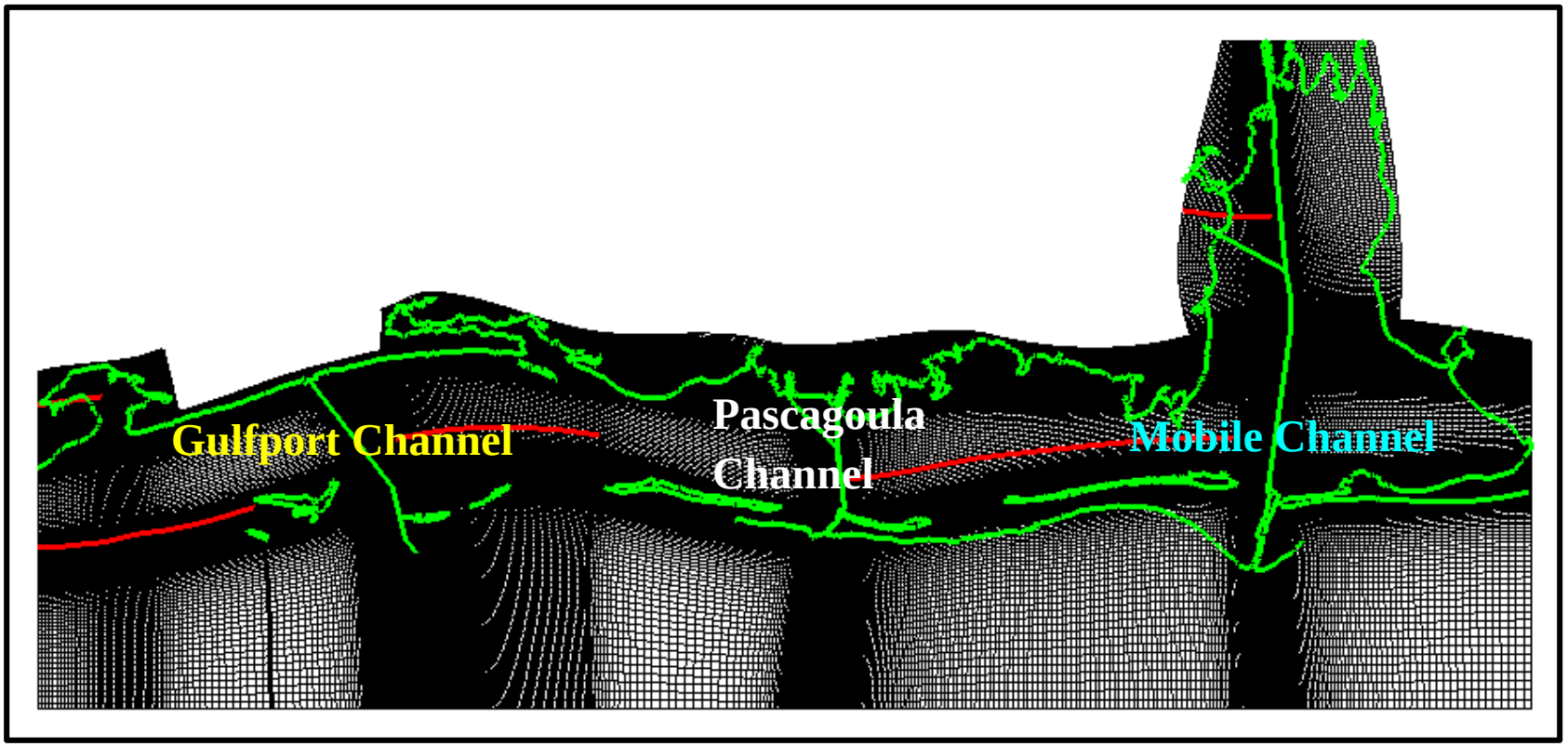


- 44,920 (total)
- 6220 (unused)
- 61X MPI-OpenMP

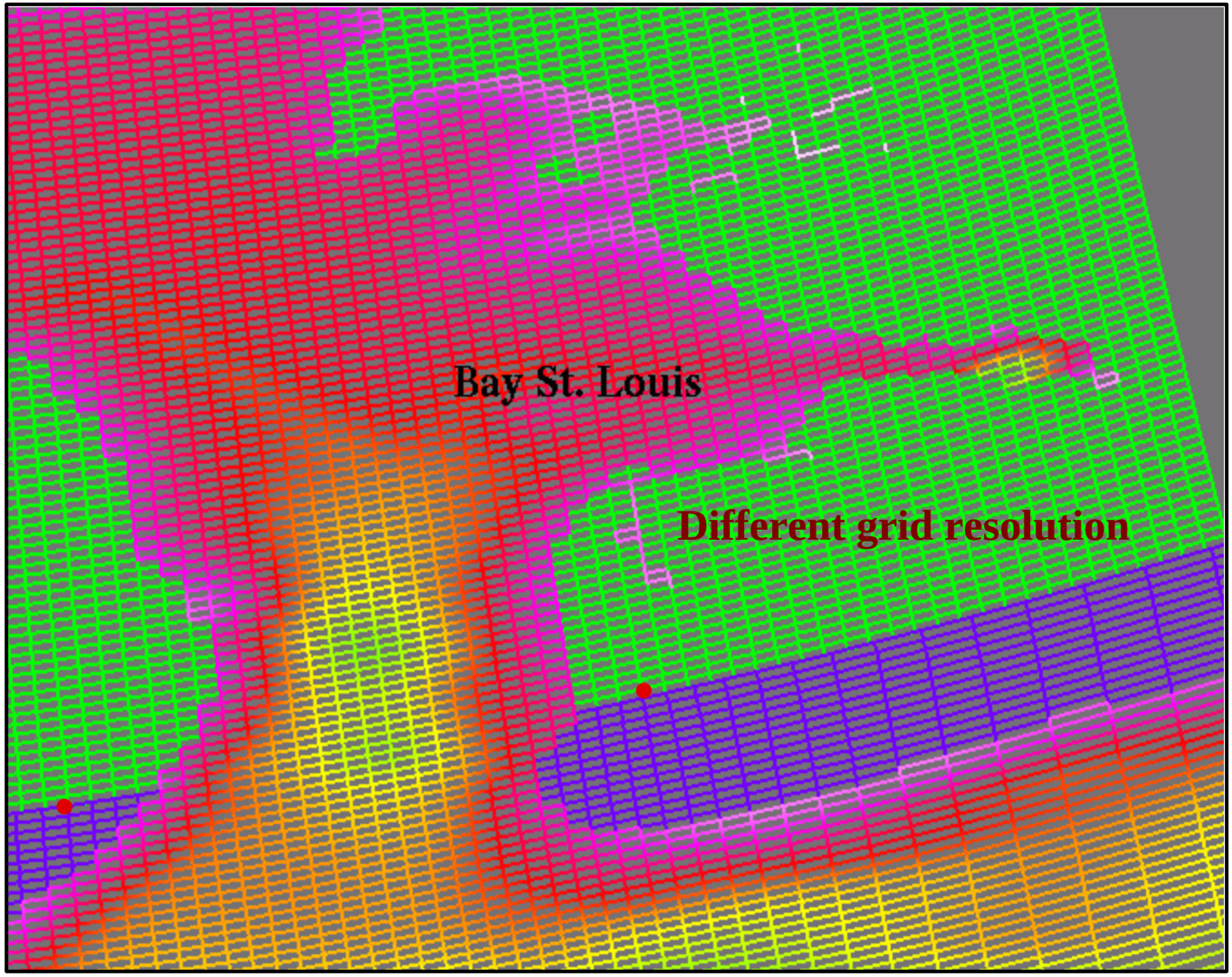
NGLI DOMAIN


Depth (m)
-41.39 -31.04 -20.69 -10.35 0.00
Mobile Channel
Pascagoula Channel
Gulfport Channel
3 arc-second resolution

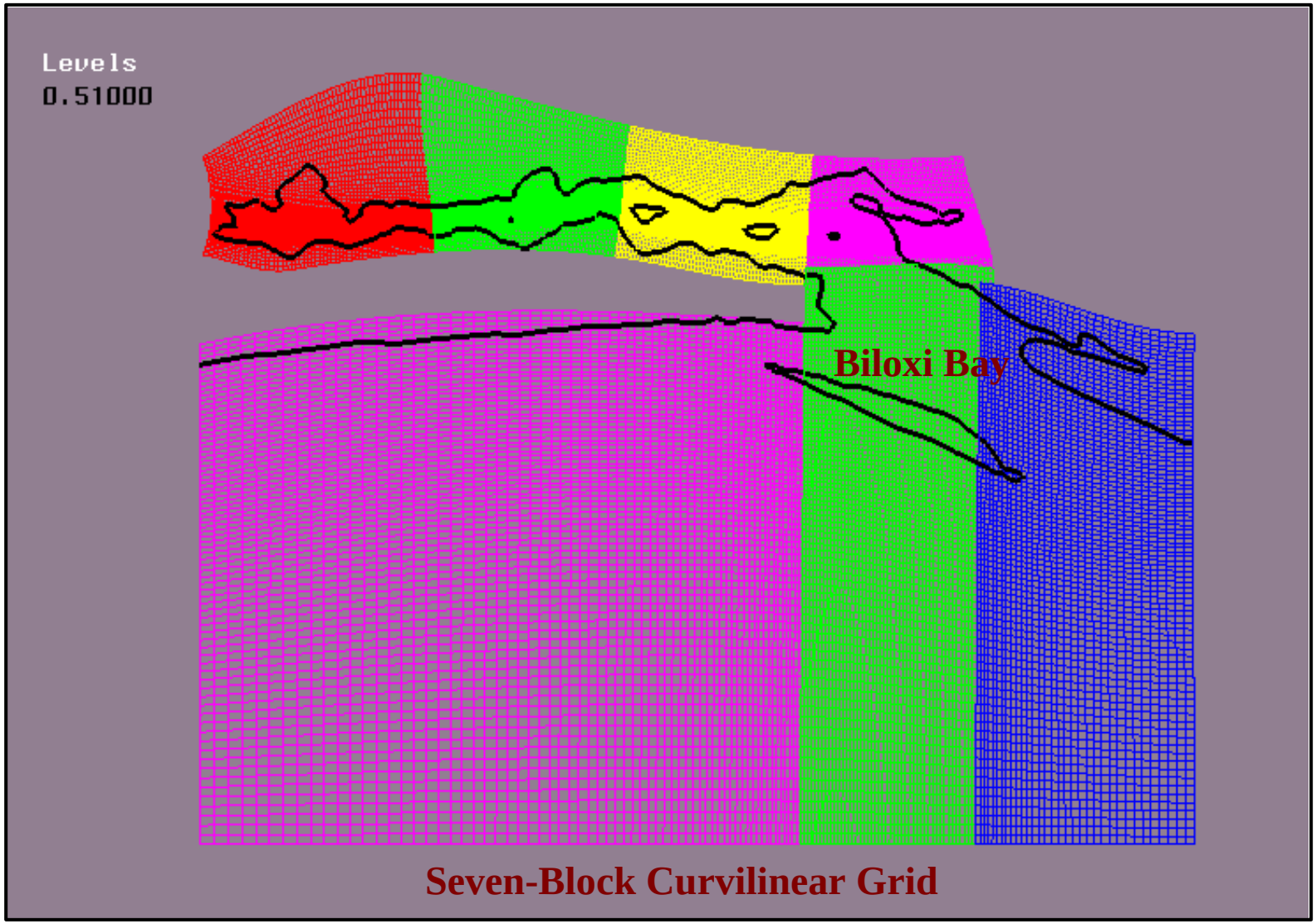
NGLI MULTIBLOCK GRID



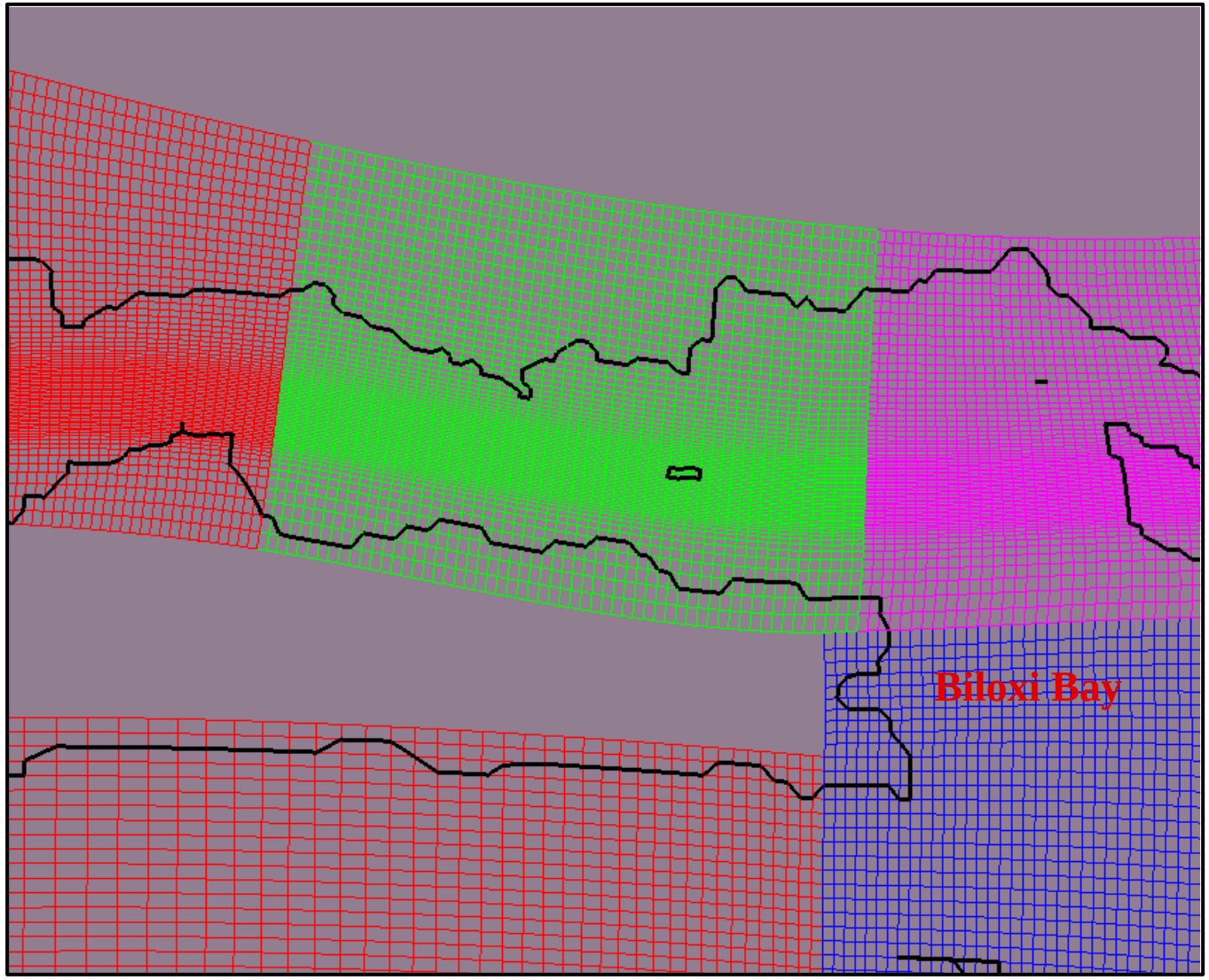
Multiblock Curvilinear Grid



Multiblock Curvilinear Grid



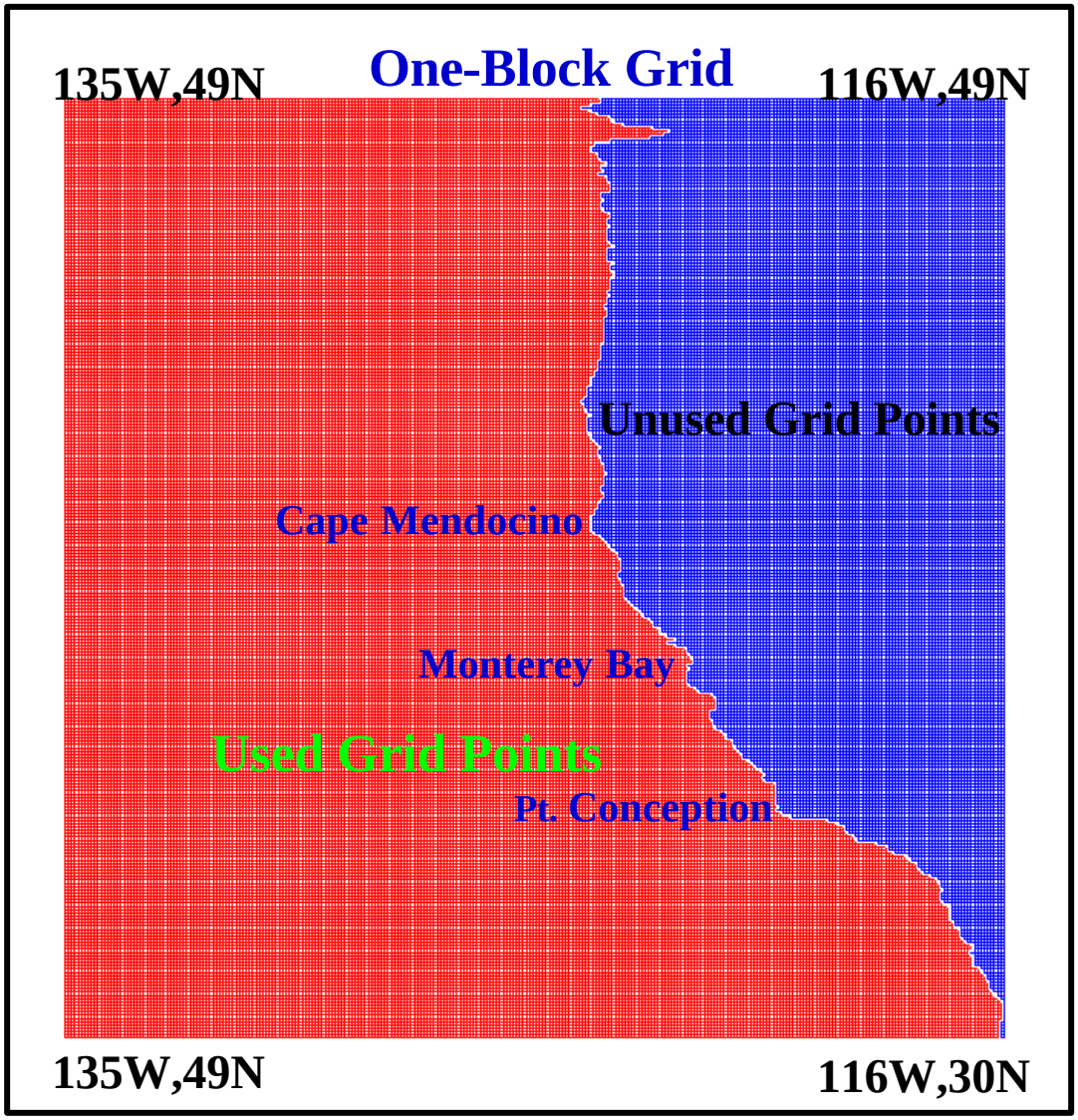
Multiblock Curvilinear Grid



U.S. West Coast Study

- Multiblock Grid Princeton Ocean Model (MGPOM)
- Four-minute resolution bathymetry data (DBDBV)
- Ten-minute resolution temperature & salinity (GDEM)
- 29-block domain decomposition grid (29DDG)
- 29-block multiblock grid (29MBG)
- Comparison:
  - Work load distribution
  - Parallel performance

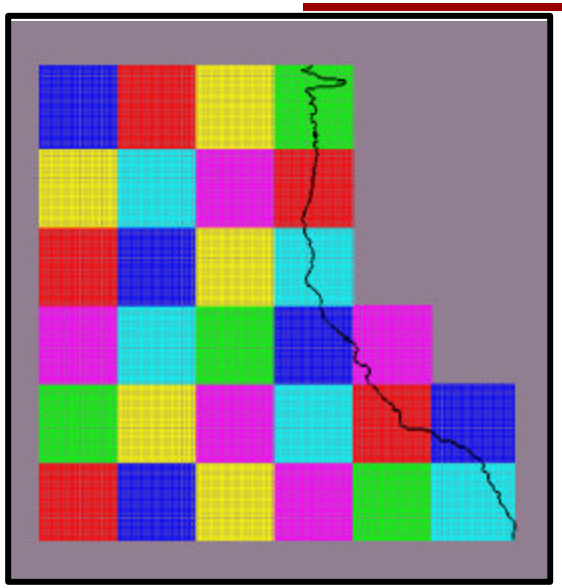
U.S. West Coast

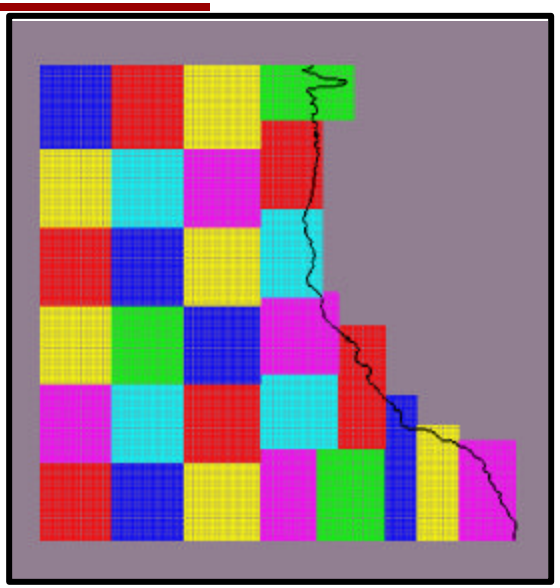


- 286x286
- 81,796 (total)
- 56,147 (used)
- 25,650 (unused)

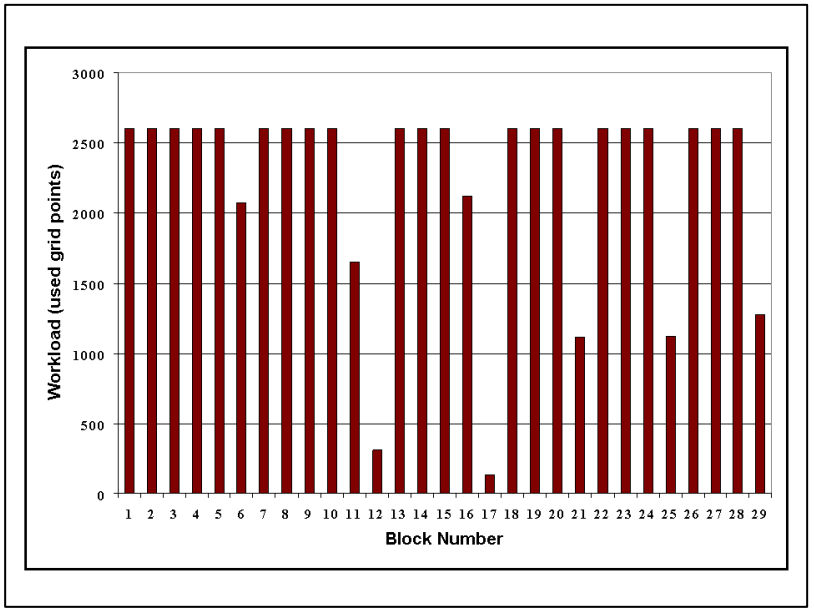
U.S. West Coast

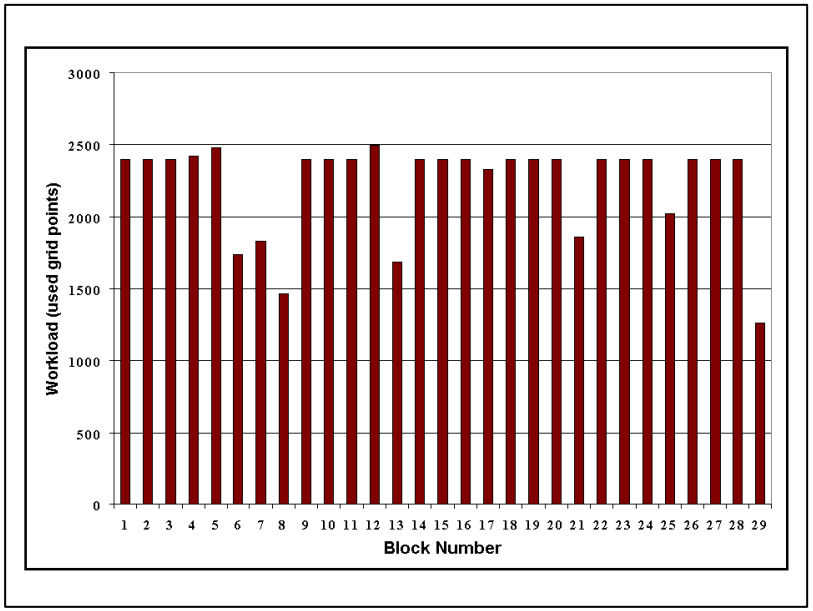
- 29DDG
- 11,015 (unused)



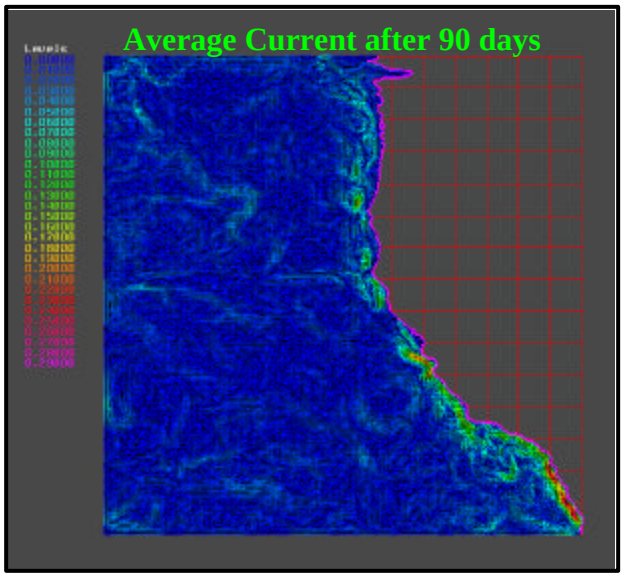


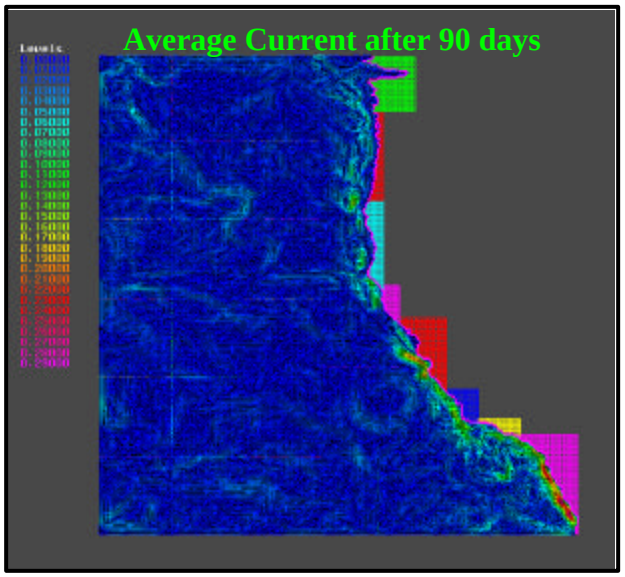
- 29MBG
- 4,007 (unused)

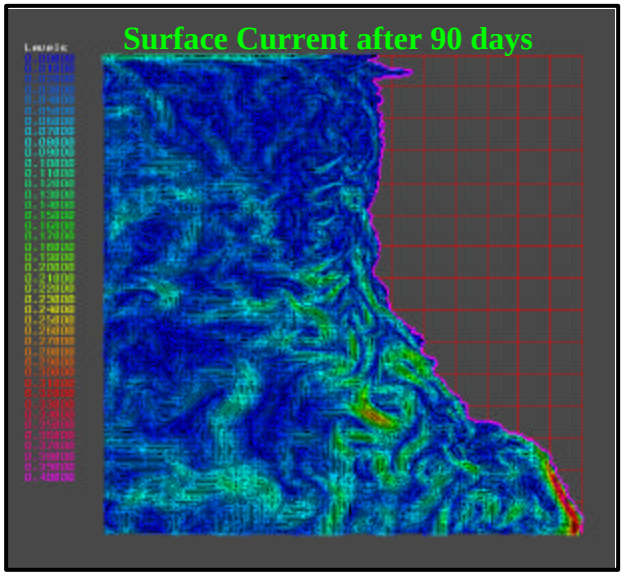


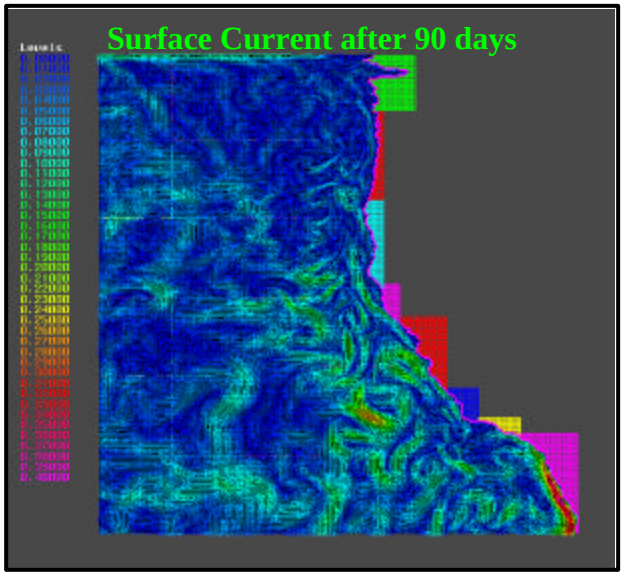


U.S. West Coast

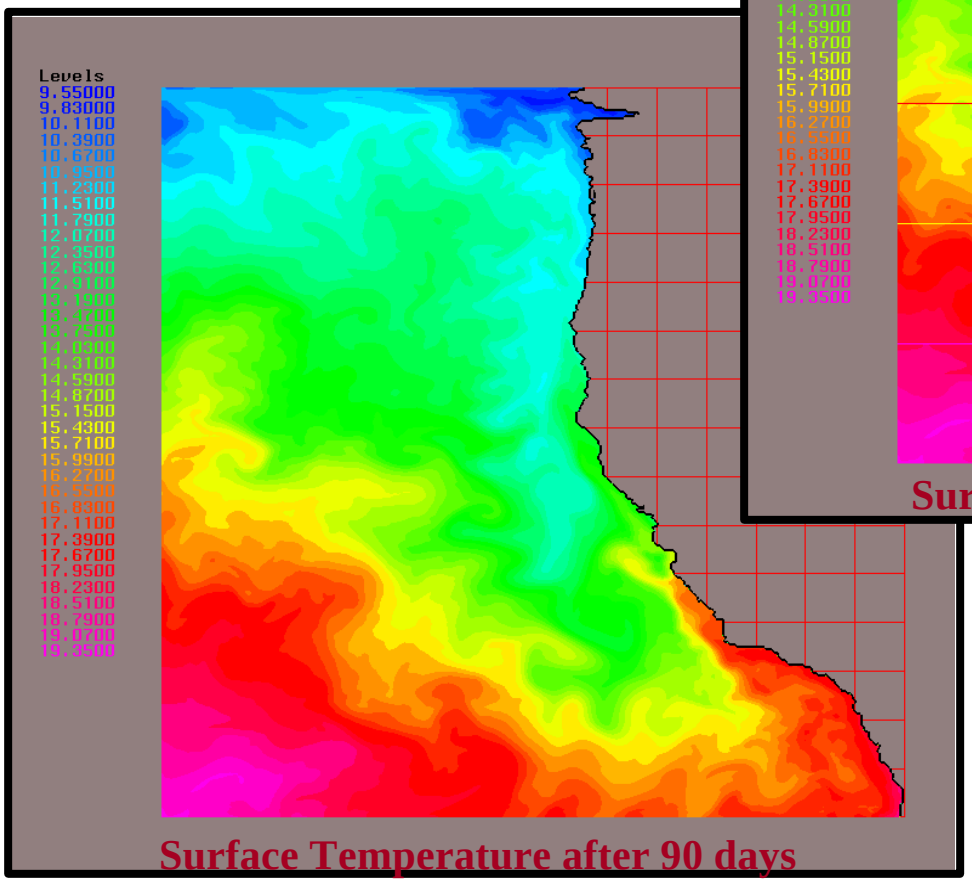




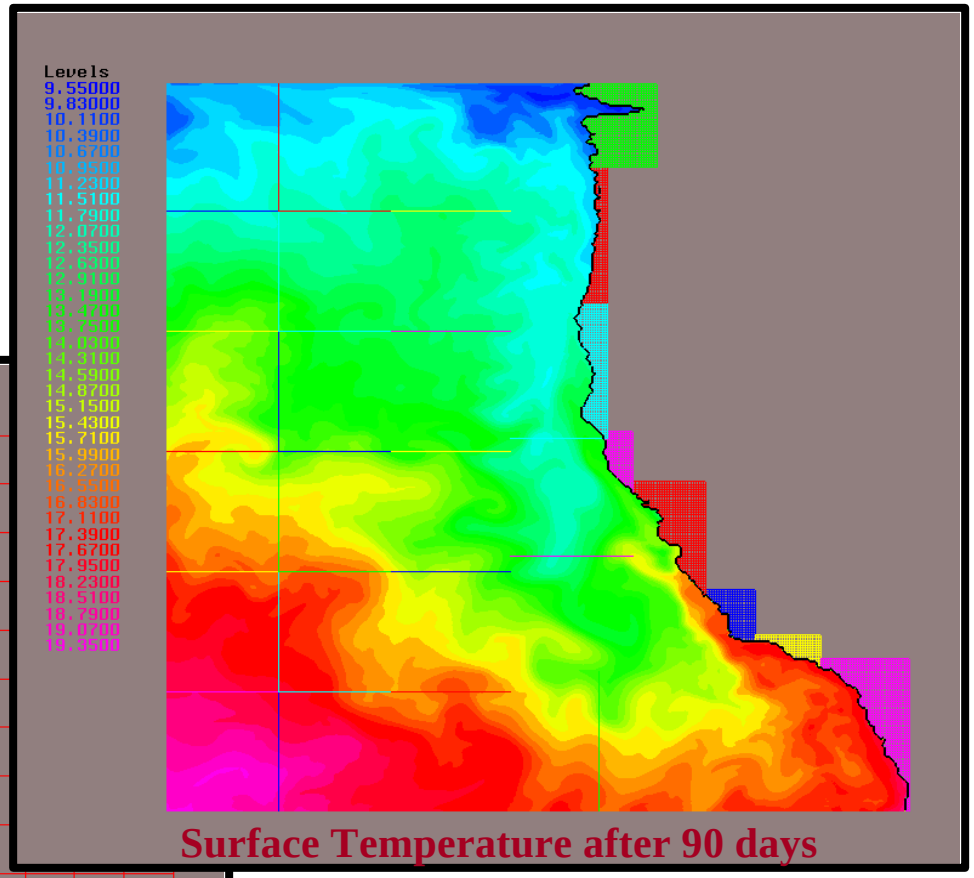




U.S. West Coast

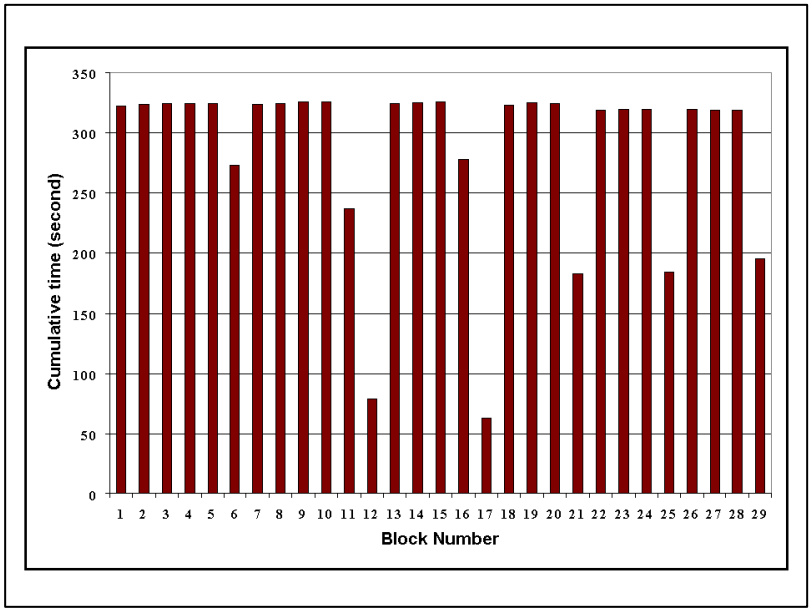


Surface Temperature after 90 days

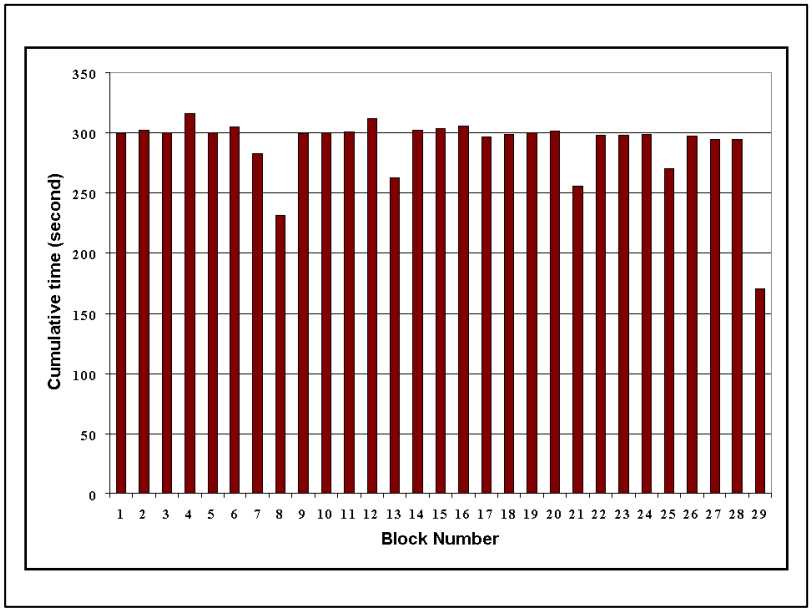


Surface Temperature after 90 days

PROFQ (MPI-Only)
Cumulative Time for (in seconds)

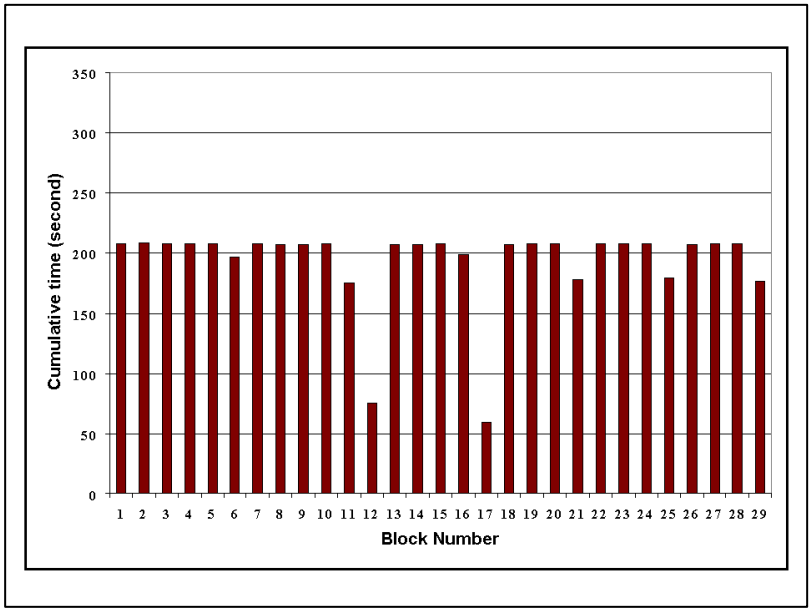


29DDG (10 days simulation)

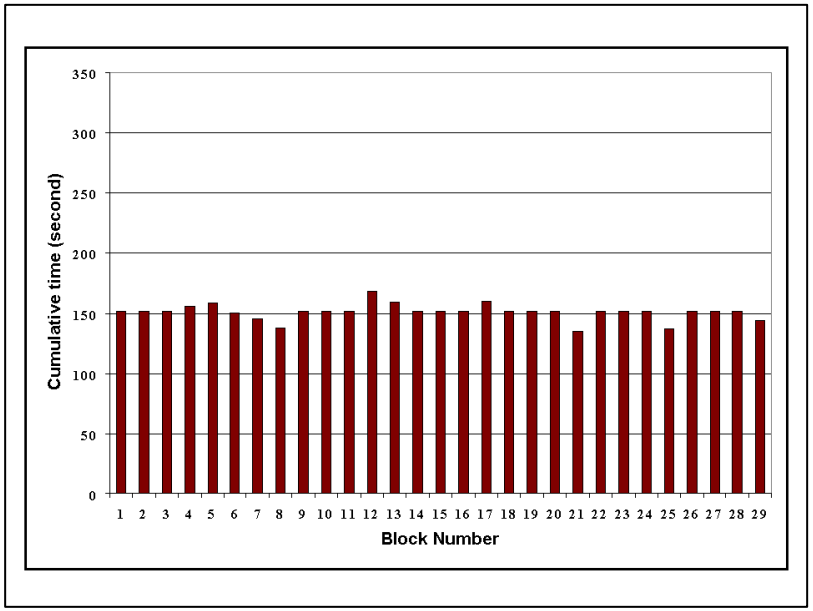


29MBG (10 days simulation)

PROFQ (MPI-Pthreads)
Cumulative Time (in seconds)



29DDG (10 days simulation)



29MBG (10 days simulation)

Performance Comparison

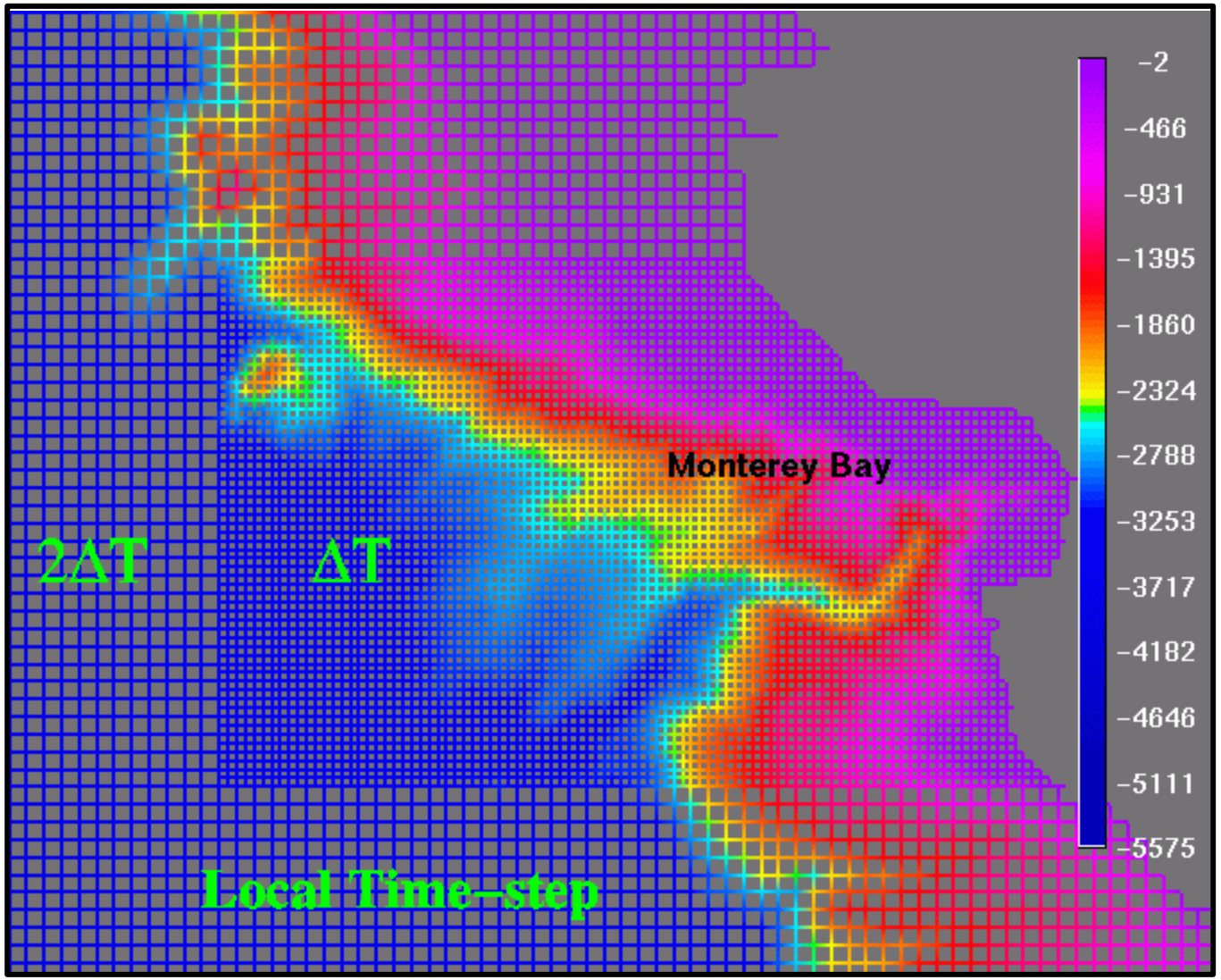
Grid Used	Implementation Method	PROFQ idle Overhead	Total Execution Time (Seconds)	Parallel Speedup	Maximum PEs Used
29DDG	MPI-Only	13	2622	26X	29
	MPI-Pthreads	7	1720	39X	58
29MBG	MPI-Only	8	2018	33X	29
	MPI-Pthreads	4	1625	41X	58

Wallclock execution time (in minutes)

Conclusions

- Numerical results are identical
- MPI-Only : 25X, 33X speedup (29 processors)
- MPI-Pthreads : 38X, 41X speedup (2PE/node)

Future Work


-2
-466
-931
-1395
-1860
-2324
-2788
-3253
-3717
-4182
-4646
-5111
-5575
Monterey Bay
2ΔT
ΔT
Local Time-step